# Validation of an anthropomorphic chest phantom for image quality control tests and dosimetry in diagnostic radiology

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## INTRODUCTION

Phantoms are defined as objects used to simulate the body organs or tissues in their interaction with radiation, and they are used to evaluate the performance and quality control of medical imaging systems [1]. These phantoms use tissue equivalent materials that simulate the tissue in their interaction with radiation [2]. In this study, an anthropomorphic chest phantom, made of artificial and no-artificial materials, was developed for studies focused on dosimetry and image quality analysis in chest radiology examinations. For validation purposes, comparisons were performed in terms of CT numbers and radiography optical densities (OD) using patient images and phantom images. For validation dosimetry, dosimetric quantities have been studied and analyzed as measurements of entrance surface air kerma (ESK) and backscatter factors (BSF), using the anthropomorphic phantom and a typical geometric phantom.

## MATERIAL AND METHODS

For this work, it was used:

- Anthropomorphic chest phantom made of epoxy resin (soft tissue simulator), a pair of lungs made of foamed polyurethane (simulator of lung tissue), and a pair of lungs, heart and chest bones, all human, which has gone through a preservation process called Glycerination, as shown in Figure 1 (A).
- Geometric acrylic phantom, with dimensions of 30 cm x 30 cm x 15 cm, as shown in Figure 1 (B).

For the realization of the validation, studies were to:

- Optical density (OD) of the radiographic image: for the analysis of DO, was obtained a radiographic image of the phantom at a posterior-anterior (PA) view using VMI equipment, Compact Plus model. The measurements were compared with OD radiographs of patients. The densitometer was used for the measurements of the Victoreen, model 07-443.
- CT Number of tomographic image: CT scans of 15 patients are used, where it was possible to make an average of every body tissue and compare this with the average CT number of phantom. The images were obtained using CT HiSpeed GE equipment and the amount of CT numbers were obtained using software DICOM Works.

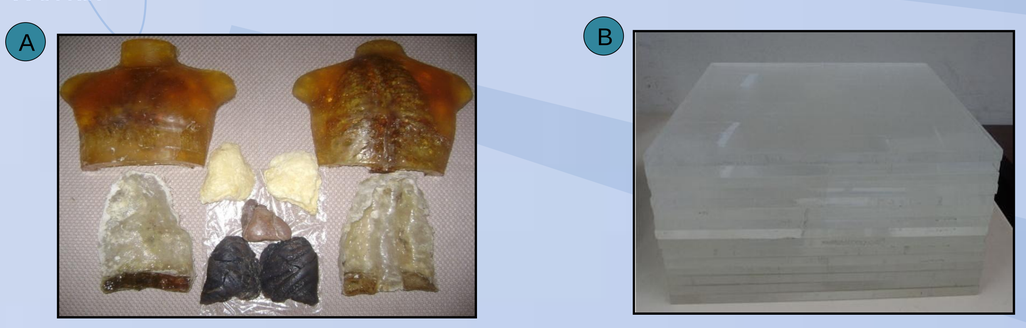


Figure 1. (A) Image of the Anthropomorphic Phantom with removable diaphragm, heart and lung real and artificial. (B) Image of the Geometric Acrylic Phantom.

- Entrance surface air kerma (ESK) measumerents: ESK measures for both phantoms were obtained for the two phantoms by ionization chamber, using VMI equipment, Compact Plus model and technical parameters for common radiological examinations of the chest;
- Backscatter factors (BSF) mesurementes: using ionization chamber, these values were determined experimentally for the two phantoms by measuring the air kerma incident.

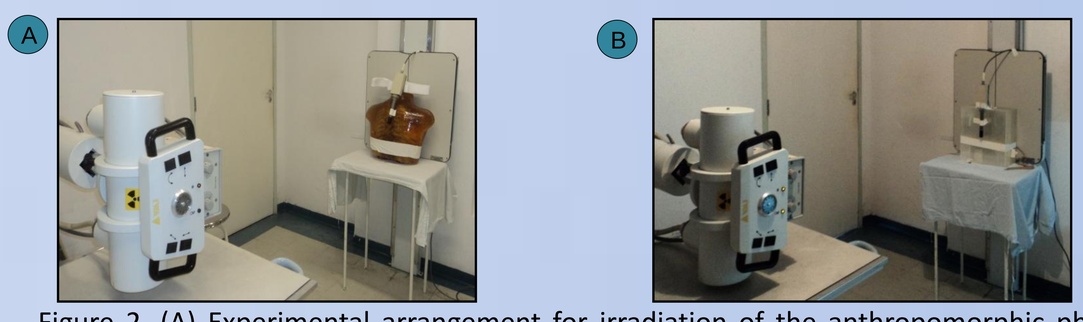


Figure 2. (A) Experimental arrangement for irradiation of the anthropomorphic phantom positioned in PA projection in conventional X-rays images and measures dosimetric. (B) Experimental arrangement for irradiation of the geometric phantom positioned.

## RESULTS AND DISCUSSION

Comparisons of results obtained in this study are presented in the following tables.

Table 1: Comparison of optical density of the phantom with the average patient.

| Tissue | Optical density OD | | | | | |
|---|---|---|---|---|---|---|
| | Phantom | | Patients | | Percentage diff. Patients/Phantom |
| Ribs | 2,007 | 0,012 | 1,956 | 0,431 | 2,5% |
| Foamed lungs | 2,050 | 0,010 | 2,221 | 0,523 | 8,3% |
| Soft tissue | 0,497 | 0,011 | 0,568 | 0,104 | 14,3% |
| Heart | 0,590 | 0,010 | 0,626 | 0,139 | 6,1% |
| Bones | 0,837 | 0,011 | 0,732 | 0,123 | 12,5% |

Table 2: Comparison of the values of CT numbers of the phantom with the average patient.

| Tissue | Mean CT numbers | | | | | |
|---|---|---|---|---|---|---|
| | Phantom | | Patients | | Percentage diff. Patients/Phantom |
| Soft tissue | 36,0 | 7,8 | 32,2 | 5,4 | 11% |
| Heart | 41,0 | 5,6 | 33,1 | 5,2 | 21% |
| Bones | 645 | 89 | 547 | 39 | 16% |
| Real Lungs | 34,8 | 5,3 | -803 | 73 | 104% |
| Foamed Lungs | -963,8 | 1,6 | -803 | 73 | 18% |

Table 3: Comparison of ESK for the anthropomorphic phantom and the phantom geometry to focus surface distance (DFS) of 150 cm and current output time of 10 mAs in the posterior anterior projection.

| Tube voltage (kVp) | ESK Values | | |
|---|---|---|---|
| | Anthropomorphic Phantom | Geometric Phantom | Percentage diff. Antr./Geom. |
| 60 | 0,1243 | 0,1310 | 5,13% |
| 70 | 0,1871 | 0,1984 | 5,73% |
| 75 | 0,2230 | 0,2329 | 4,23% |
| 80 | 0,2538 | 0,2729 | 7,02% |
| 90 | 0,3393 | 0,3614 | 6,11% |

Table 4: Comparison of BSF for the anthropomorphic phantom and the phantom geometry to focus surface distance (DFS) of 150 cm and current output time of 10 mAs in the posterior anterior projection.

| Tube voltage (kVp) | BSF Values | | |
|---|---|---|---|
| | Anthropomorphic Phantom | Geometric Phantom | Percentage diff. Antr./Geom. |
| 60 | 1,2523 | 1,3200 | 5,13% |
| 70 | 1,2821 | 1,3600 | 5,73% |
| 75 | 1,2975 | 1,3548 | 4,23% |
| 80 | 1,2748 | 1,3711 | 7,02% |
| 90 | 1,3224 | 1,4085 | 6,11% |

In the aspect of image quality, comparisons of OD values and the CT numbers showed good similarity between the final imagens, except for CT number of the lungs that had real big difference. For the dosimetric aspect, the values found of ESK and BSF, also showed good approximation when comparing the two phantoms.

## CONCLUSIONS

The results found prove the efficacy of the phantom for image quality control tests and dosimetry in diagnostic radiology. This phantom can to using in routine quality control testing of medical imaging, because the OD e CT numbers are near those obtained in tests on real patients. Moreover, the anthropomorphic chest phantom was useful and applicable for dsoimetry studies and professional training.

## REFERENCES

[1] International Commission on Radiation Units and Measurement. Tissue Substitutes in Radiation Dosimetry and Measurement. ICRU Report 44. Bethesda, MD: ICRU; 1989.
[2] International Commission on Radiation Units and Measurements. Phantoms and models in therapy, diagnosis and protection. ICRU Report 48. Bethesda, MD: ICRU; 1992.

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